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A MACHINE FOR APPLICATION OF DUST TO CUT SEED POTATOES

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INTRODUCTION

For a decade or more a few potato growers have been using various dust formulations to treat freshly cut seed potatoes. In recent years, with the advent of new chemicals, research plant pathologists have had favorable responses with certain dust treatments. A. P. Benson^{2/} summarized the status of seed piece treating as follows:

"The value of potato seed treatment depends on whether or not treatment of the seed is necessary to attain a good stand. If weather conditions are ideal, the seed disease free, and a 100 per cent stand can be attained without treatment, then seed treatment is, obviously, of no benefit. However, if the weather is wet and cold, or the seed disease ridden, and a stand of only 60 per cent is attainable without treatment, then seed treatment is necessary.

"There is a considerable amount of conflicting evidence on the effectiveness of seed-piece treatment. Results of continued experiments are extremely difficult to interpret. This may be true because the environmental factors vary from year to year and the seed tubers may not be handled in the same manner every year.

"Seed piece-treatment is used to protect the seed piece mainly from two diseases--blackleg (a bacterial disease) and seed-piece decay (usually a fungal disease). These seedling diseases will result in reduced yields.

"The effect of the use of fungicide on seed pieces will be influenced by the condition of the seed (as affected by storage, disease, etc.), the general planting and handling processes (cutting and storage of the cut seed pieces, use of cut or whole seed), and general growing conditions (soil temperature, time required to emerge, soil moisture, etc.)."

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Seed potatoes are usually cut inside a potato storage. Proximity to the supply of seed potatoes is an important reason for this location of the seed potato cutting operation. From the standpoint of providing a comfortable environment for the workers, particularly in the northern potato growing areas, locating the cutting operation inside a building is desirable.

Before the advent of mechanical potato harvesters, cut seed potatoes were transported to the field in burlap bags. The hopper-bottom truck boxes, developed primarily for receiving potatoes from the harvester, have been adapted to handling cut seed potatoes, thus eliminating the use of burlap bags for this purpose. A conveyor is used for loading the truck with the cut seed pieces as fast as they are cut with a mechanical seed potato cutter.

Various methods and a variety of types of equipment are used in applying dust to the freshly cut seed pieces. The simplest but least effective method is to sprinkle dust from time to time on top of the seed pieces as they accumulate in the truck. A somewhat more effective method uses a dust metering device located above a belt that conveys the cut seed pieces from the seed potato cutter to the truck box. Still another commercial treater uses an inclined rotating drum and some kind of dust metering device. The freshly cut seed potatoes and dust are introduced continuously into the raised end of the drum. The drum is mounted at such height above the floor as required to discharge the potatoes from the lower end of the drum into the hopper of a conveyor which delivers the treated seed pieces into a hopper-bottom truck box. From the standpoint of completeness of coverage, this drum type of treater can be entirely satisfactory, but as with other methods in commercial use, the dust is not confined within the treater.

Although the dust formulations currently used for treating cut seed potatoes may not be highly toxic, it is important to prevent emission of dust into the space occupied by the workers. Inhalation of dust-laden air over an extended period can be a hazard to health even if the dust is nothing more than the inert materials used as diluents with the chemical compounds used for treating the seed potatoes.

OBJECTIVES IN THE DESIGN OF AN EXPERIMENTAL SEED POTATO TREATER

The experimental machine herein described was designed for testing certain principles to determine if they could be incorporated into a machine for commercial use. The primary requirements for a satisfactory commercial seed potato treater are considered to be:

1. Adequate and uniform dust coverage of the cut surfaces of the seed pieces without excessive wastage of dust.
2. Adequate capacity (60 cwt. or more per hour).
3. Confinement of the dust to prevent pollution of the air breathed by workers.

Obviously, any successful commercial machine must be designed so that it is sufficiently durable to be reasonably free from mechanical failures. Also, it should be constructed with standard parts insofar as possible. These requirements would be essential in the design of a prototype of a commercial product, but they are not of primary importance in an experimental unit. On the other hand, certain features required in an experimental machine are not necessary, or even desirable, in one that is considered to be a prototype of a commercial model. For instance, one of the objectives of conducting tests with the experimental unit was the determination of the ratio of dust to cut seed potatoes required for effective coverage of the cut surfaces with dust. This required a precision dust metering device with provision for adjustment by small increments, and one with which desired dust feeding rates are reliably reproducible. The dust metering device designed to accomplish this could be used on a commercial machine, but one somewhat less precise would probably be just as satisfactory.

BASIC ELEMENTS

The experimental seed potato treater consists of the following basic elements:

1. A conveyor for continuous introduction of cut seed pieces into the treating chamber.
2. A dust hopper and metering device for continuous introduction of dust into the treating chamber.
3. An inclined rotating drum which functions as a treating chamber and conveyor for continuous movement of the seed pieces through the machine.
4. A flat belt conveyor for removal of the treated seed pieces.
5. A housing (5-D) which encloses the rotating drum and through which the upper side of the flat belt passes.
6. A fan to maintain a slight differential in air pressure between the inside and outside of the treater.
7. A cloth filter through which air passes to the intake of the fan (6). Filter is enclosed in housing (5-F) which is an extension of housing (5-D).

Elements 1, 2, and 3, only are essential to the primary purpose of the treater, namely, coating the cut surfaces of the seed pieces with dust. Elements 4, 5, 6, and 7 are essential for the method employed to confine the dust within the system.

The method utilized to prevent emission of the dust-laden air from inside the treater is basically quite simple. In a continuous treater, there must be two openings--one through which the seed pieces and dust are admitted and the other for removal of the treated seed pieces. These two openings permit diffusion of air between the inside of the treating chamber and the outside unless some measures are taken to prevent this happening.

In this experimental treater for cut seed potatoes, the emission of dust-laden air is prevented by maintaining a low-velocity movement of air from the outside to the inside of the treater through the opening required for entrance of the untreated seed pieces and dust and the opening for exit of the treated product.

Figure 1 is a schematic illustration of the basic functional elements of the experimental seed potato treater. The conveyor (not shown) delivers freshly cut seed pieces into chute from which they pass through opening in housing (5-D) into upper end of rotating drum (3). The dust metering device (2) delivers a continuous flow of dust through a flat rectangular duct which reaches to the upper side of the opening in the housing (5-D). Dust falls on the cut seed pieces as they pass under the vertical dust delivery duct. Four cleats inside the drum cause the seed pieces to tumble as the drum rotates. The seed pieces drop from the lower end of the drum onto a flat belt (4) which carries them through an opening in the housing (5-D), and delivers them into the hopper of an elevating conveyor.

The blower (6) intake is connected by a flexible air duct to housing (5-F) which encloses a cloth filter (7). Thus, air is drawn into the housing (5-D) through openings required for entrance and exit of the seed pieces. Since there is a positive inward movement of air through all openings in the housing, there can be no diffusion of dust-laden air between the inside and outside. All of the air coming out of the housing is passed through the filter (7).

Figures 2 to 7 are photographs of the experimental unit. The numbers in parentheses used to identify various parts in the photographs correspond to the identification numbers of the functional elements of figure 1.

TEST RESULTS

The experimental dust applicator for cut seed pieces was used in the spring of 1965 to treat 300 cwt. of cut seed potatoes of the Red Pontiac variety. Tests were conducted to evaluate the results with dust application rates ranging from 1/2 to 1 1/2-pounds per 100 pounds of cut seed potatoes. The dust used in this series of tests was a formulation made up with calcium carbonate dust used as a diluent. Ninety-eight percent of the dust would pass through a 325-mesh screen. The uncompacted bulk density was 60 pounds per cubic foot.

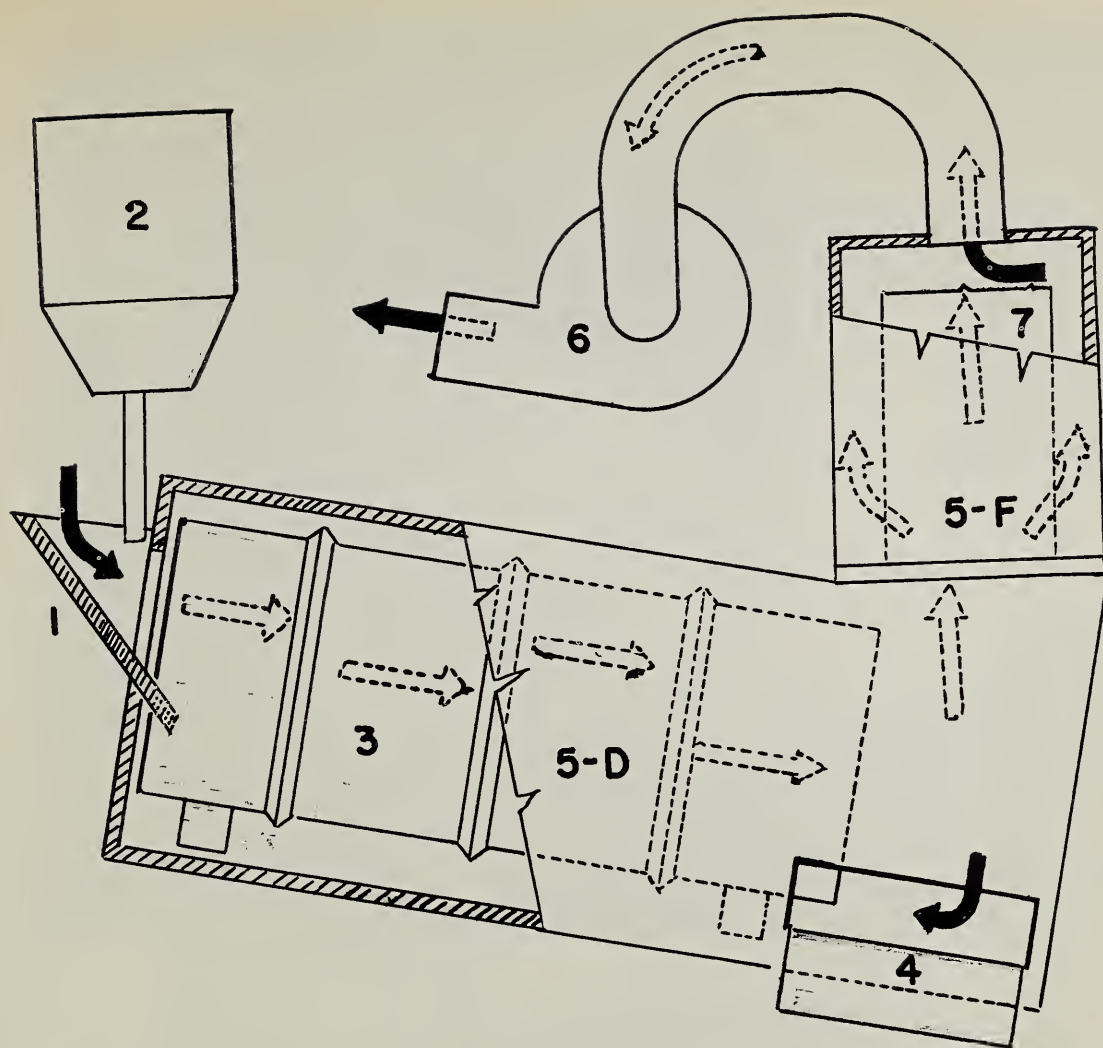


Figure 1. Schematic illustration of seed-potato treater showing air flow pattern.

1. Cut seed-piece input chute.
2. Dust hopper and metering device.
3. Rotating drum treating chamber.
4. Flat belt for removal of treated seed pieces.
- 5-D. Drum housing.
- 5-F. Filter housing.
6. Centrifugal fan.
7. Cloth filter.

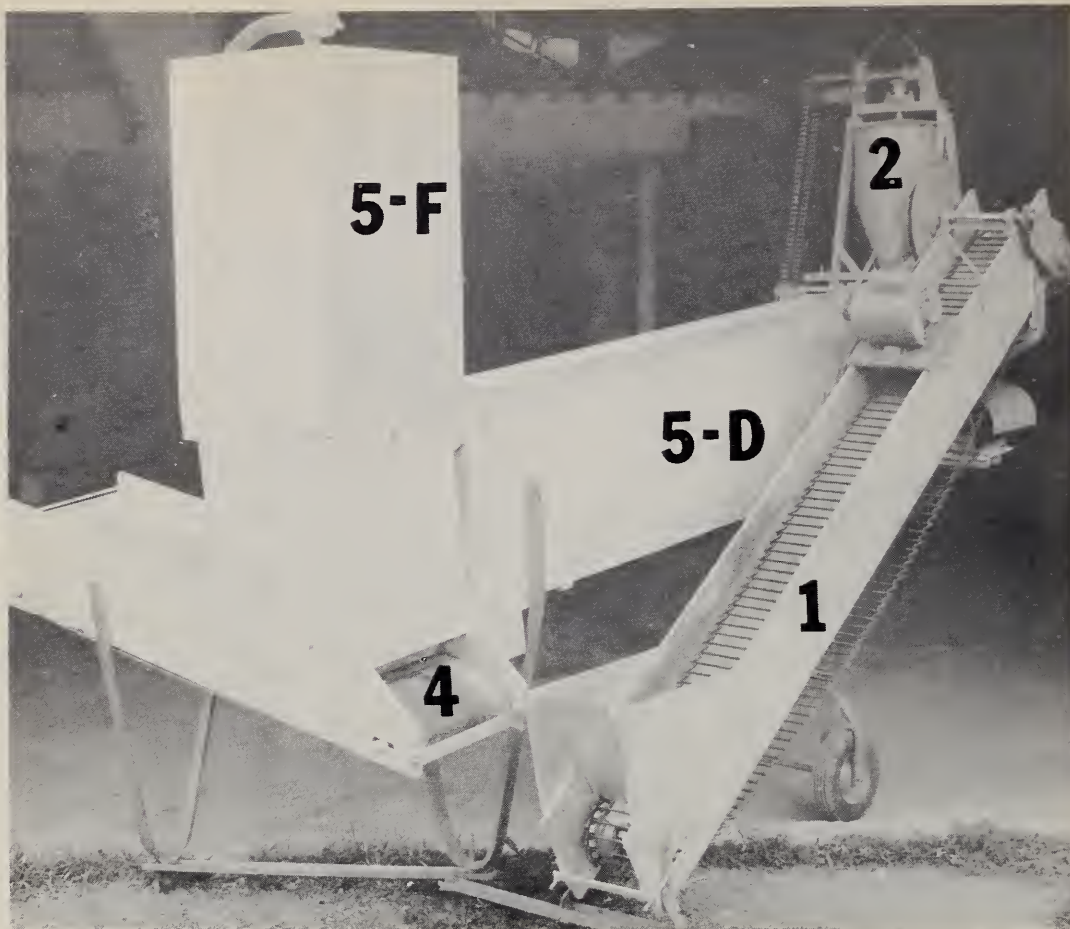


Figure 2. In this photograph, the machine is completely assembled. The conveyor (1), with its driving motor, is supported at both ends in a manner that permits it to be readily removed. The cover on the housing 5-D is held in place with toggle-type latches so it can be easily removed. Filter housing (5-F) is similarly held in place and is likewise readily removed.

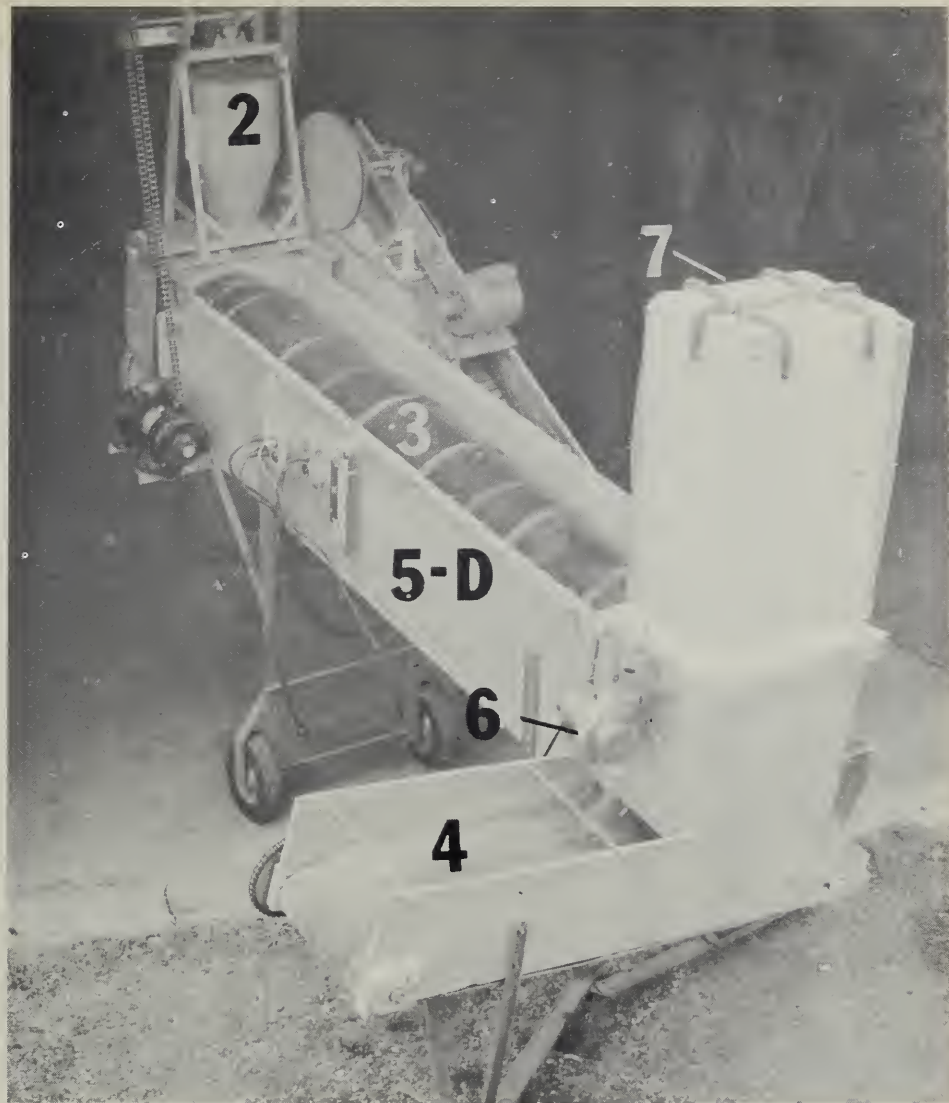


Figure 3. Filter housing 5-F and cover of housing 5-D removed. The drum (3) can now be lifted out of the housing. Because of the possibility of buildup of dust on the inside of the drum, easy removal of the drum for cleaning is important. Inside the filter (7) is a horizontally positioned rectangular frame supported by two perpendicular rods. The lower ends of the rods are attached to a rectangular frame which matches the opening in the housing over the belt (4). A screen sleeve encloses the filter.

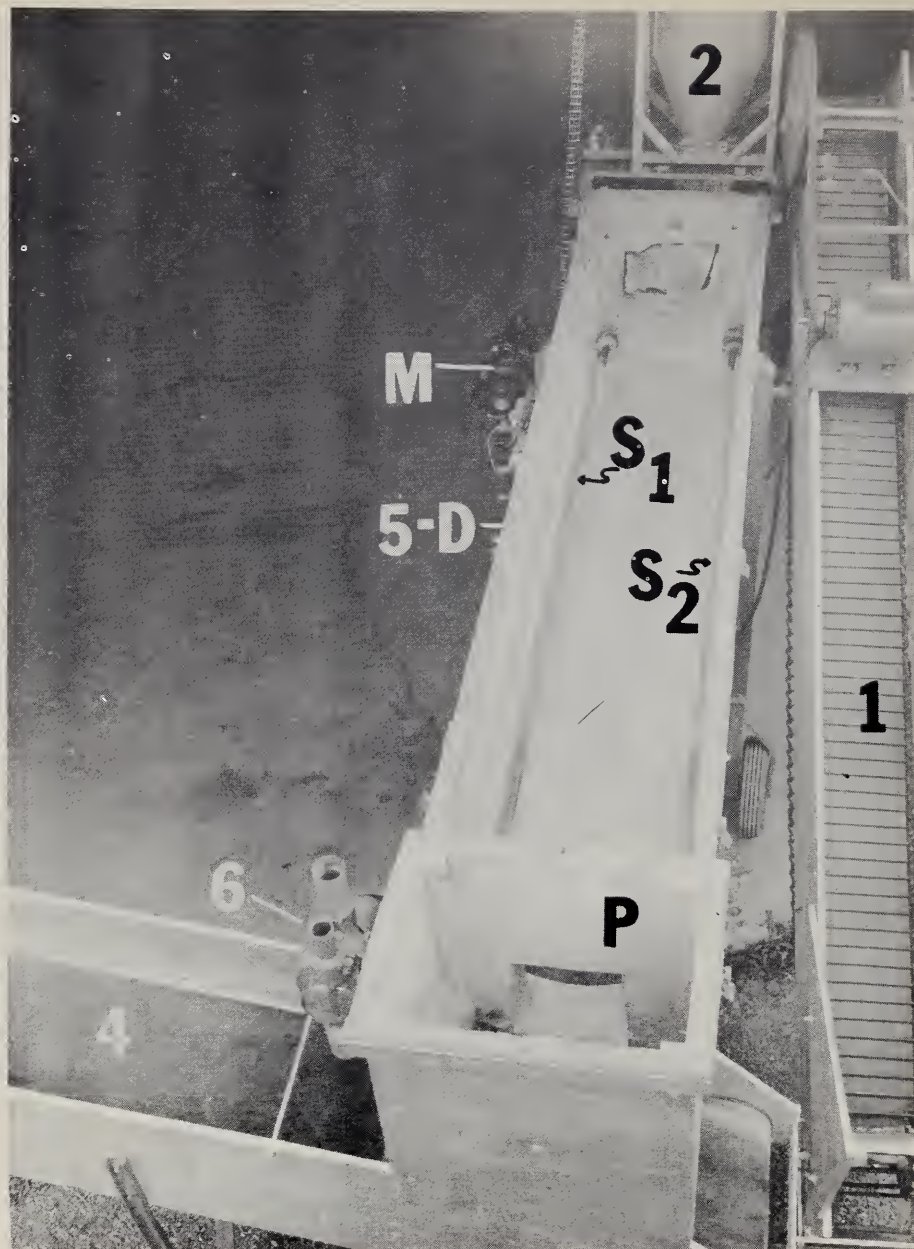


Figure 4. Filter and drum are removed. Two shafts (S_1 and S_2), parallel to the axis of the drum, are located near the bottom of the housing (5-D). Inside, and near each end of housing (5-D), rubber rollers with steel hubs are mounted on the shafts. The drum is supported and driven by these four rollers. The shafts (S_1 and S_2) are supported by flange-type ball bearings attached to ends of the housing (5-D). The seed pieces pass from the rotating drum through an opening in the partition (P) and drop on the transverse conveyor belt (4). The cover over the conveyor belt on the left side of the housing has been removed. It is in place in figure 2.

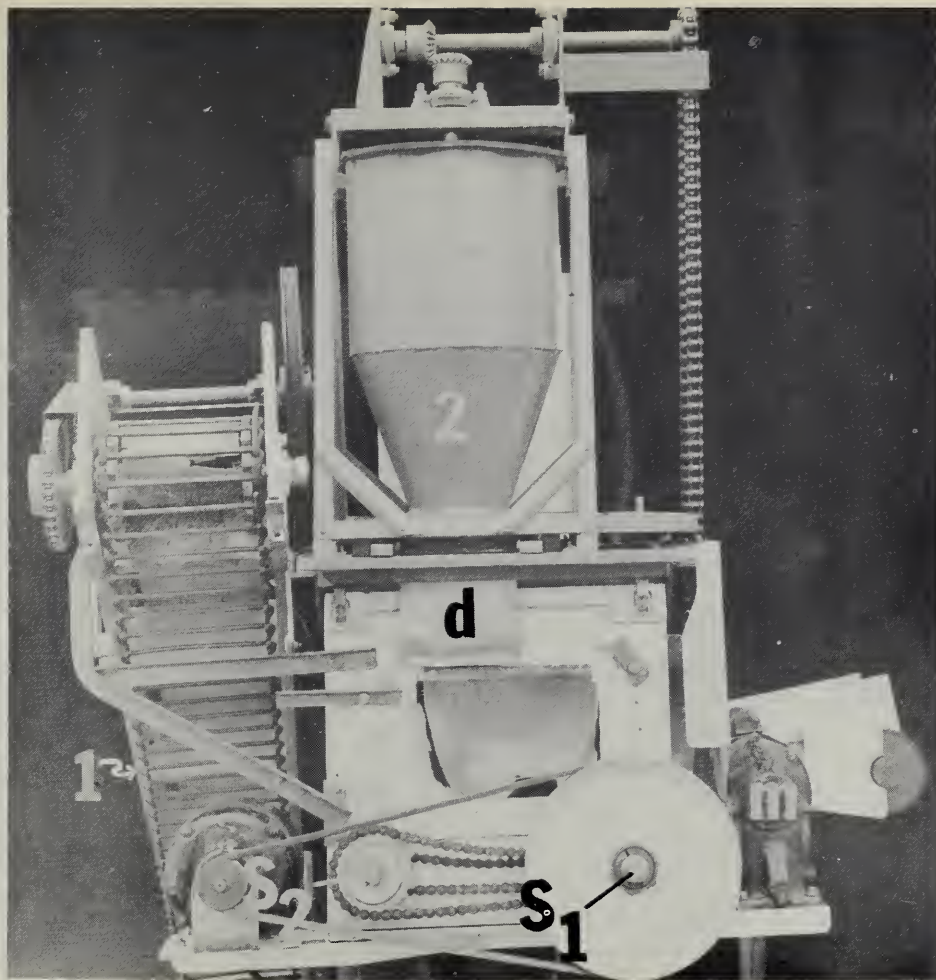


Figure 5. Seed piece input chute and the chain and belt guard removed to show construction details. The purpose of the canvas flap is to reduce the effective area of the opening in respect to air movement. The large v-belt sheave and a roller chain sprocket are fixed on a hub which turns freely on shaft (S_1). A roller chain from the sprocket on the hub drives (S_2). Another sprocket on (S_2) drives a sprocket of the same size fixed on (S_1). The overall reduction from the motor to the shafts, (S_1 and S_2), results in a rotational speed of 31 r.p.m. for the drum. The flat rectangular duct (d) terminates at the upper edge of the opening into the drum housing.

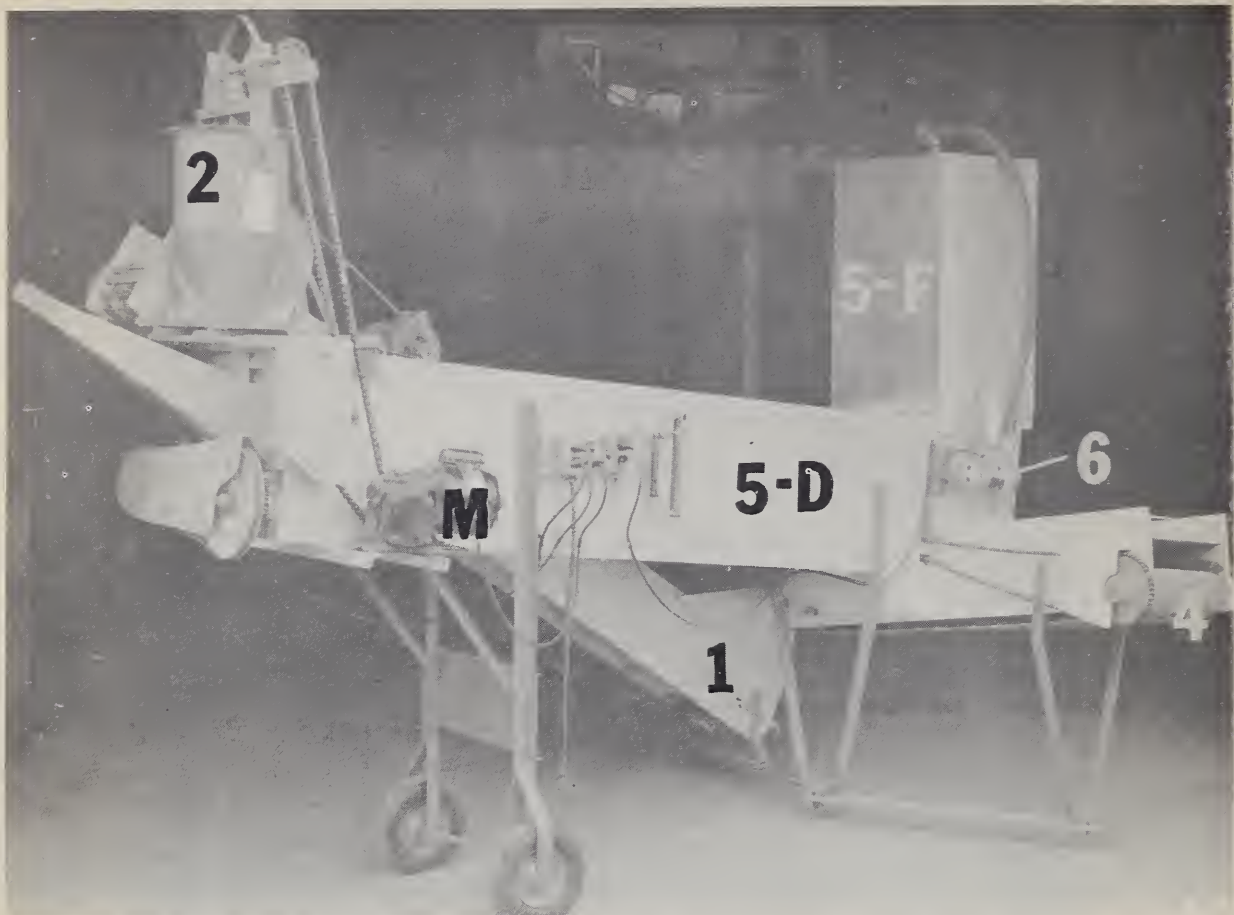


Figure 6. Completely assembled unit. Dust metering unit is driven by motor (M) through integral speed reducer. A vacuum cleaner motor and fan (6) draws air from the system through cloth filter (7, fig. 3). A variable resistor is connected in series with the vacuum cleaner motor to provide a means of reducing the fan speed.



Figure 7. Treated seed pieces discharged from treater into conveyor hopper.

Seed potato cutting and treating were carried on simultaneously in a continuous operation at the rate of 24 cwt. of potatoes per hour. The dust discharge rates used were 0.2, 0.3, 0.4, 0.5, and 0.6 pound per minute. The dust metering device had been previously calibrated and the accuracy of the desired rate was checked by actual weight of dust delivered in one minute whenever the setting was changed. The dust delivery rates indicated above resulted in application rates of 0.5, 0.75, 1.0, 1.25, and 1.5 pounds of dust per 100 pounds of potatoes. The input of freshly cut seed pieces remained constant at 24 cwt. per hour.

At each rate of dust application, random samples of treated seed pieces were collected as they dropped from the delivery belt. After the dust delivery rate was changed and checked for accuracy, approximately 600 pounds of seed pieces were processed at the new rate of application before the samples were collected.

The samples were taken to the laboratory where thin sections were removed from individual seed pieces for microscopic examination to evaluate the effectiveness of coverage of the cut surfaces with dust. Eight seed pieces, collected in a random manner with each rate of application, were thus examined. None of the samples examined displayed any areas not covered with dust. The surfaces examined appeared to be completely covered, but not uniformly within minute areas viewed through the microscope. The dust layers were observed to vary in depth. As would be expected, the apparent depth of coverage was more or less correlated with the dust application rate.

The results of this series of tests indicate that, with reasonably clean seed potatoes, complete coverage of the cut surfaces may be obtained with as little as 1/2 pound of dust per 100 pounds of cut seed pieces. It was also demonstrated that there is considerable latitude between the minimum required for complete coverage and the amount that would result in wastage of dust due to failure of excess dust to adhere to the surfaces of the seed pieces. It is to be emphasized that for these tests only one dust formulation was used, and more or less dust could be required with some other formulation. Several other diluents besides calcium carbonate are used in commercial dust formulations.

The tests conducted in 1965 were limited to a processing rate of 24 cwt. of potatoes per hour because that was the capacity of the seed potato cutter used in these tests. In 1966, about 1,400 cwt. of seed potatoes were processed at this rate at the research farm of the Red River Valley Potato Growers' Association. The experimental dust treater was then moved into the warehouse of a commercial potato grower where the cutting rate was 70 cwt. per hour. The dust metering device was adjusted to deliver 0.6 pound of dust per minute, which amounted to slightly more than 0.5 pound of dust per 100 pounds of seed potatoes. A microscopic examination of randomly collected seed pieces revealed something less than complete coverage of the cut surfaces. The dust application rate was, therefore, increased to 1 pound of dust per 100 pounds of seed potatoes, and samples of seed pieces were subjected to microscopic examination. Coverage of the cut surfaces was apparently complete with the increased application rate. This lot of seed potatoes was exceptionally dirty. Due to high soil-moisture conditions which prevailed throughout the harvest season in 1965, unusual amounts of soil adhered to the tubers.

Approximately 2,100 cwt. of cut seed potatoes were treated at a rate of 70 cwt. per hour.

The testing of this experimental machine is considered to be completed. The performance indicates that it meets the three functional requirements initially established for a satisfactory commercial unit. Some presently used commercial seed potato treaters have adequate capacity and achieve satisfactory coverage of the cut surfaces. None, insofar as the author knows, confine the dust to prevent contamination of the air within the building wherein the seed potato cutting and treating is carried on. Tests with the experimental machine have demonstrated that, in addition to achieving satisfactory coverage and capacity, the dust is completely confined within the treater.

SPECIFICATIONS

As indicated earlier, the machine herein described is an experimental unit and should not be regarded as a prototype of a commercial product. The translation of principles developed and tested in an experimental unit may result in a commercial product of substantially different configuration. Therefore, working drawings, with details and dimensions, have not been developed. It is believed that some general information about the basic elements can be of more value in the development of a commercial prototype.

1. Conveyor for introduction of seed pieces into rotating drum.

This conveyor uses a rod apron 7 1/2 inches wide with a chain pitch of 1.28 inches. The apron slides over a solid bottom panel which prevents the loss of thin seed pieces that could pass between the links. Through belt and chain speed reductions to the upper apron shaft, a 1/4 h.p. motor drives the apron at a linear velocity of 70 feet per minute.

2. Dust hopper and metering device. As previously indicated, this dust metering device was constructed especially for the purpose of testing this experimental treater. It is adjustable for delivery rates from zero to 1.2 pounds per minute. It is believed that there are commercial units available which would be satisfactory, so a detailed description of this dust metering unit will not be included.

3. Inclined rotating drum. This drum has an inside diameter of 13 3/4 inches and a length of 76 1/2 inches. It is inclined at an angle of 10° and rotates 31 r.p.m. Inside the drum are four cleats made of B-section v-beltting. These are arranged so as to form four equally spaced helices with a pitch of one-fourth turn in 76 inches. The four rubber-faced rollers mounted on shafts S₁ and S₂ (fig. 4) are 2 1/4 inches in diameter. They support and rotate the drum. Shafts S₁ and S₂ turn 191 r.p.m. to rotate the drum 31 r.p.m. No other speeds were used, but it is probable that the treating capacity would be increased with a higher rotational velocity of the drum. The 70 cwt. per hour processed with the experimental treater does not necessarily indicate the maximum capacity at 31 r.p.m. This was the highest seed potato cutting rate available.

4. Flat belt conveyor. This belt, which carries the treated seed pieces from the machine, is 12 inches wide. It is carried on slightly crowned sheaves made up with rods. This construction avoids the trouble that might occur with buildup of dirt on the faces of solid face sheaves. The belt travel is 60 feet per minute.

5. Housing for rotating drum and belt (4). The function of the enclosure for the drum and belt is illustrated in figure 1. The openings required for the introduction of the freshly cut seed pieces and for removal of the treated seed pieces should be no larger than necessary. The input opening is approximately 7 x 8 inches. The outlet opening, through which the flat belt passes is 2 1/2 x 12 inches. The effective areas for air movement are reduced by flexible canvas flaps which permit passage of the seed pieces, but offer some restriction to air movement.

Housing 5-F is essentially an extension of 5-D. The partition, with an opening for passage of potatoes from the drum, is not essential from the standpoint of control of air and dust. It serves as a structural member and the flange-type bearings for shafts S_1 and S_2 are attached to it. This partition is of double wall construction. Shaft S_1 projects through the bearing and the forward wall. Flat belt (4) is driven from shaft S_1 .

The cover is held in place with eight toggle-type latches. The removal of a cotter pin permits the dust hopper and metering assembly to be moved forward so that the cover and drum can be readily removed. Provision for easy removal of the drum is considered to be important because of the possibility of a buildup of dirt and dust on the interior of the drum, necessitating occasional cleaning.

Housing 5-F, which encloses the cloth filter, is also held in place with latches that permit easy removal.

6. Fan for drawing air from system. The fan draws air from housings (5-D and 5-F) and exhausts it to the atmosphere. The air intake of the fan is connected to the top of housing (5-F) inside of which is a cloth filter (7). Dust in the air is removed by the filter. The air drawn out by the fan is replaced by the same amount which enters through the openings provided for the entrance and exit of the seed pieces and any joints which may not be entirely airtight. The capacity of the fan need only be sufficient to maintain just enough inward movement of air through these openings to prevent diffusion of air between the inside and outside of the housing. There is a disadvantage in using a fan of considerably greater capacity than required. The filter will become loaded with dust, which may or may not be critical, depending on the area of the filter and the material of which it is made.

For the experimental machine, a vacuum cleaner motor and fan were used. A variable resistor was installed in the motor circuit to provide a means of regulating the motor speed and fan capacity. The fan speed was adjusted to a point where smoke tests indicated a perceptible

inward movement of air at the inlet and outlet for the seed pieces. The air velocity discharged from the fan was measured with a velocity meter and the quantity was calculated to be 25.2 cu. ft. per minute.

7. Cloth filter through which air passes to the intake of the fan. The filter is made of muslin cloth woven with 67 threads per inch in each direction. It is not cloth especially made for use as a filter. (The material used was originally a bedsheet.) We might not filter out all of the dust if the air velocity through the filter was considerably greater. The area of the filter is 12 square feet and with air movement through the filter of only 25.2 c.f.m. the resulting velocity through the filter is low. The air pressure drop through the filter with the fan moving 25.2 c.f.m. was 0.02 inch of water. This measurement was made after the filter was cleaned by shaking at the end of the season. No measurements of resistance were made with it loaded with dust, but the slight pressure drop measured indicates that the maximum possible buildup of dust on the filter would not seriously reduce the volume of air drawn through the filter. The vertical position of the filter surfaces limits the amount of dust buildup that can occur. Figure 8 shows the instrumentation and method of measuring the air pressure drop through the filter.

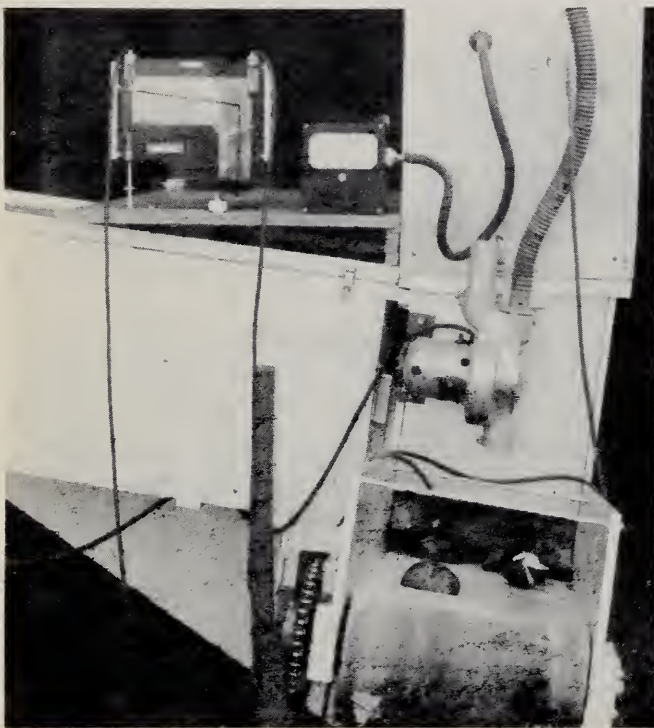


Figure 8. Measurement of resistance to airflow through filter. An inclined tube manometer and a moving vane anemometer indicated a pressure drop of 0.2 inch of water where the air discharged from the blower was 25.2 c.f.m.

The rectangular shape of the filter used on the experimental unit required a screen sleeve to prevent the cloth from being drawn against the sides of the housing. With a cylindrical filter in a cylindrical housing, a screen sleeve would not be needed.

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